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Fig. 2 contains regression plots for my data[2] on pairs found in nature and for laboratory matings in mass experiments, the length-classes having been redistributed according to their respective values in terms of the "normal" length. This procedure involves the assumption that the proportion of flattening in the "artificial" method is the same for animals of the same size-class at different seasons, which is probably not quite exact. The original records were obtained in April–May, 1917, whereas the data for Fig. 1 were secured in September, 1918. In the presence of so many possible sources of variation as these measurements permit, it is sufficient to "average" the determinations graphically, each original length-class, and the corresponding mean length of the mates of individuals in this class, being treated as units in reducing the old "length" figures to the more natural ones obtained through Fig. 1.

According to Fig. 2, the apparent intensity of homogamy in Chromodoris is but little affected, if anything perhaps slightly improved, by the reduction of the original figures to the natural scale.

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THE ORIGIN OF THE INTOLERANCE OF INBREEDING IN MAIZE

THE marked intolerance of inbreeding in maize has recently been discussed by Collins[1] and brought to the support of the hypothesis that this plant is of hybrid origin. But to those who look for the origin of maize in another direction, the problem is capable of a very different solution.

Briefly stated, Collins' argument is this: Most varieties of maize suffer from a few generations of self-pollination, but teosinte does not seem to be affected by this treatment. The maize plant as a whole is usually synacmic, with a tendency toward protandry, and self-pollination is in a large degree possible; such inflorescences of maize as have both stamens and pistils are distinctly protogynous. In teosinte the large number of inflorescences on a single plant makes self-pollination a common thing. If maize arose from teosinte, what was the origin of its intolerance of inbreeding? The assumption that maize is of hybrid origin takes care of this difficulty by attributing this genetic peculiarity to the unknown parent, which hybridized with teosinte, and in which cross-pollination was probably secured by protogyny.

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[1] Collins, G. N., "Intolerance of Maize to Self-fertilization," *Jour. Washington Acad. Sci.*, 9: 309–312, 1919.

Three fallacies render this argument inapplicable to the problem that it attempts to solve:

1. We are at once confronted with a question as to how maize, embarrassed by its well-known intolerance of inbreeding and by the extensive self-pollination with which Collins characterizes it, has persisted through the ages. The answer is that self-pollination in the plant is not so common as would be inferred from Collins' discussion.

It is true that a single isolated plant is largely self-pollenized, if pollenized at all, but data derived from the single-stalk culture often practised in experimental work can not be accepted as a criterion, for maize is normally grown in hills, and probably has been for a very long time. This method of cultivation is described by every early explorer and writer on Indian agriculture and seems to have been the rule from the garden beds of the Great Lakes region to the terraced mountain slopes of Peru. In many instances as many as eight or ten plants were grown in a single hill. This was the outgrowth of the Indian's limitations in the way of implements and domesticable animals, and the plant was well adapted to it. The method was adopted by civilized man and is extensively employed, with but few modifications, to the present day.[2]

If all the plants in a hill were synacmic and flowered at the same time and the air were motionless, the chances for self-pollination would vary inversely as the number of plants in a hill. Tendencies toward protandry, coupled with slight differences in the time of flowering of the individual plants of a hill, the prevalence of winds, and the proximity of other hills increase the chances for cross-pollination. Growing the plants in hills also discourages the production of suckers, thus reducing the number of inflorescences on a single plant, and consequently the chances for self-pollination.

This massing of plants together in hills, and of hills together in fields, is admittedly an artificial element of environment; but its possible evolutionary effect in the ages during which it has prevailed can not be disregarded. What the condition was in wild maize no one knows, and there is little basis for speculation. But the plant has probably been in cultivation quite long enough to have had its character shaped by agricultural practise.

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[2] Cates, H. R., ''Farm Practice in the Cultivation of Corn,'' U. S. Dept. Agr. Bull. 320, 1916, pp. 19–21.

Directly in accord with this theoretical consideration are Waller's researches,[3] which indicate that when corn is grown in hills under ordinary field conditions, self-pollination occurs, on the average, in only a little more than five per cent. of the seeds. As Waller suggests, these figures may be modified by further work on the problem. There is no evidence, however, that the percentage of self-pollination will ultimately be found to be significantly larger than this. The genetic complexity of the average plant selected at random from any ordinary agricultural variety of maize is a standing evidence of the prevalence of cross-pollination.

2. The origin of protogyny in the androgynous inflorescences of maize need not be sought outside the Maydeæ. This is the regular condition in *Tripsacum*, at least in *Tripsacum dactyloides*, which is the only species that I have had opportunity to examine in flower, and it occasionally occurs in *Euchlœna*. Collins[4] and Kempton[5] disregard or question the existence of androgynous inflorescences in the latter genus, but the fact of their occasional occurrence remains. The lowest inflorescences of a teosinte plant are almost always wholly pistillate, and the highest wholly staminate. Perfect flowers have not been observed, but between the pistillate and staminate units androgynous inflorescences often occur. These are regularly protogynous. Androgynous inflorescences terminating the main culm are often produced in the greenhouse. The difference between greenhouse plants and those grown in the open in Mexico or southern Florida is fully appreciated. Androgynous terminal inflorescences are certainly of rare occurrence there, if they occur at all; but I am not sure but that they are of less frequent occurrence also in maize grown in tropical or sub-tropical countries. Monœcism in the Maydeæ is readily influenced by environment. The physiological conditions conducive to androgyny in the tassels of maize, and to a relative increase in the number of pis-

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[3] Waller, A. E., "A Method of Determining the Percentage of Self-pollination in Maize," *Jour. Amer. Soc. Agron.*, 9, 35–37, 1917.

[4] *Loc. cit.* Also Collins, G. N., "The Origin of Maize," *Jour. Washington Acad. Sci.*, 2: 520–530, 1912.

[5] Kempton, J. H., "The Ancestry of Maize," *Jour. Washington Acad. Sci.*, 9: 3–11, 1919.

tillate flowers in *Coix* and *Sclerachne,* also produce androgyny in the inflorescence of teosinte. This fact may be of some significance. Maize was doubtless originally a tropical plant. How much of its erratic floral behavior when grown in temperate latitudes is due to real, fundamental differences between it and teosinte, and how much to environment?

It seems, then, that as to androgyny or as to protogyny of the individual inflorescence, there is no fundamental difference between maize and the other American representatives of the Maydeæ. When this fact is coupled with a reduction in the number of inflorescences, as in maize, it becomes unnecessary to assume the introduction of the intolerance of self-pollination from another group.

3. Collins leaves in this paper, as well as in an earlier one,[6] the impression that the alternative to his hybrid origin hypothesis is the theory that maize originated as a mutant from teosinte. The latter idea is quite as chimerical as the former. We can not reasonably hope to find the ancestor of maize in any modern plant; phylogenetic histories seldom work out in this way. The logical procedure is to look for other plants which may have descended, coordinately with maize, from a common ancestor. In *Tripsacum* and *Euchlœna* we find two genera that fill the requirements in all known details.[7]

The intolerance of inbreeding in maize is probably the plant's natural evolutionary response to its environment. The maize plant is unique among the grasses in bearing but one pistillate and one staminate inflorescence, or at most only a few inflorescences of each type, in having these widely separated, and in having been grown in hills for untold centuries. These conditions all tend toward extensive cross-pollination, and the data at hand indicate that cross-pollination is the rule. More or less adjustment to these structural characters and this mode of living would be expected; and the decline in vigor, resulting from inbreeding, may be interpreted as the natural consequence of an abnormal and unfavorable condition.

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[6] Collins, G. N., ''Maize: Its Origin and Relationships,'' *Jour. Washington Acad. Sci.,* 8: 42–43, 1918.

[7] Weatherwax, Paul, ''The Evolution of Maize,'' *Bull. Torrey Club,* 45: 309–342, 1918.